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Machining Method and Machining Device

The present invention pertains to a machining method and a machining device for components, especially body parts, with the features in the preamble of the principal claim.

Such machining devices are known from practice, e.g., as welding robots. They comprise a multiaxial transport means in the form of an articulated arm robot and a tool, e.g., a welding tool. Furthermore, it is known from practice in the case of machining stations for body parts, especially so-called geo stations or framing stations for tacking the body parts, that stationary or mobile lateral clamping frames, which may be equipped with a plurality of clamping tools, are used to clamp the components. However, these clamping frames can be attached to the vehicle body or the body parts only on the outside, so that only outer clamping is correspondingly possible. This must be taken into consideration in designing the body and in the concept of the manufacturing process. Moreover, the accessibility of the components for external welding robots or the like is limited. Clamping body parts on the inside is not possible.

The object of the present invention is to show a better machining technique.

This object is accomplished by the present invention with the features of the principal method claim and the principal device claim. The claimed machining device and technology has the advantage that it has a multifunctional field of use. It forms a so-called multirobot, which can carry out a great

variety of activities at different sites and especially joining, clamping or machining sites of the body parts. Moreover, it is possible as a result to carry out a plurality of joining processes on the inside of the vehicle body or the components. In particular, it is possible to clamp a vehicle body on the inside.

The multirobot has the advantage that each machining unit with its tool, which may optionally be replaceable, is mobile and able to function independently and is freely programmable. As a result, many different functions can be carried out by the multirobot or the machining units thereof independently from one another. Moreover, this has the advantage that only a single clamping device, which requires only a different programming in case of a changeover to another type, is needed for all the vehicle bodies to be manufactured.

The multiaxial machining units arranged at the multirobot can have a very large working range thanks to their freely selectable multiaxial nature. A correspondingly adapted shape of the carrier is also helpful for this. The use of small robots, preferably in the form of small articulated arm robots with six or more axes, is especially advantageous here, especially because standard components can be used for this embodiment of the machining devices. All the kinematic requirements can be satisfied even for a changeover to components of another type due to the highly flexible multiaxial nature with six or more axes, e.g., a seventh telescopic axis for the robot hand. Not even a change of location on the carrier is necessary in case of the small robots being claimed. A change in location and re-assembly on the carrier can be carried out as an alternative in case of simpler machining units.

Furthermore, it is possible to equip a machining station, e.g., a geo station or a framing station, with one or more of these multirobots, which offers special advantages for the accessibility of the body parts. The clamping effort on the outside of the body parts can be reduced due to an inside clamping technique, which improves and facilitates the accessibility of the body to other machining or processing devices, e.g., welding robots or the like. Moreover, welding processes or other joining processes can be carried out on the inside of the body more easily and with better quality due to the multiaxial small robots. The multirobot can place the carrier with the small robots in a suitable manner in the interior space of the body. The small robots also have improved accessibility to hidden or hard-to-reach areas of components located on the inside, which are hardly accessible for a welding robot or the like that is arranged on the outside. The outside dimensions of the carrier and the small robots can be reduced such that they can be fed through openings in the component or in the body and placed in the interior space.

In the working position, the carrier can be held by the transport means freely floating or additionally supported at the free end or at another suitable site. Firm support and guiding or mobile support with degrees of freedom in one or more directions or axes may take place. This permits the carrier and its small robots to be re-oriented into different positions.

Additional advantageous embodiments of the present invention are described in the subclaims.

The present invention is schematically shown in the drawings as an example. Specifically,

Figure 1 shows a perspective view of a machining station with a multirobot,

Figure 2	shows a side view of the multirobot,
Figure 3	shows a top view of the multirobot from Figure 2,
Figures 4 and 5	show a side view and a rear view, respectively, of a small robot, and
Figure 6	shows a top view of the multirobot in the working position in a body.

Figure 1 shows a machining station (1) for components (2), which [station] may have any desired suitable design. In the exemplary embodiment being shown, it is a geo station or framing station for body parts (2), for example, side panels and floor group, which are brought into the machining station (1) on a pallet or another suitable carrier by means of a conveyor, not shown, and positioned here exactly in a position suitable for machining. The machining station (1) may be part of a larger production plant and integrated in this case within a transfer line formed by a plurality of stations.

One or more external clamping frames (4), for example, the two side frames shown in Figure 1, which are docked with the station frame (3) or alternatively with the pallet in a suitable and accurately positioned manner, may be present in the machining station (1) for clamping the body parts (2).

A plurality of machining devices (5, 12) are present in the machining station (1). These may be, for example, process devices, especially the welding robots (12) shown, which are arranged externally and in a floor-bound manner laterally next to or on a portal above the body parts (2) and the clamping frames (4). The welding robots (12) are preferably designed as articulated arm robots with six or more axes, optionally also linear auxiliary axes. The robots (12) carry suitable and optionally replaceable tools, for example, welding devices, which may, however, also be designed

in any other suitable manner.

At least one special machining device (5) in the form of a so-called multirobot is arranged in the machining station (1). The multirobot (5) comprises a mobile transport means (6), which is preferably designed as a transport robot. This is preferably an articulated arm robot with six rotatory axes. The transport robot (6) may be arranged, for example, as a portal robot suspended on the station frame (3) and it is located as a result in a central location above the transfer line and may consequently also be oriented centrally and in the direction of the longitudinal axis of the body parts (2). As an alternative, the transport means (6) may also be designed in any other desired manner, for example, as a multiaxial linear unit. The number of axes may vary as well. At least two axes that are movable independently from one another are advantageous.

The transport means (6) carries a docked multi-arm unit. This comprises at least one carrier (7), at which one or more multiaxial machining units (8, 9) with at least one tool (11) each are arranged.

The carrier (7) is detachably connected with a suitable connection of the transport means (6), preferably the robot hand (13) of the transport robot. In particular, a change coupling may be arranged here, which makes possible the automatic replacement of the carrier (7) with another carrier or another tool. The carrier (7) may be a one-part or multipart carrier and is preferably of a rigid and bending resistant design. It may have any desired suitable shape adapted to the machining task. As an alternative, the carrier (7) may comprise a plurality of parts with corresponding drives, which said parts can be moved, e.g., folded or telescoped relative to one another in a controlled manner and can be locked in the selected position.

In the exemplary embodiment being shown, the carrier (7) is designed as an essentially straight, box-shaped girder with closed wall. As an alternative, the carrier (7) may have a singly or multiply bent, curved and/or optionally branched shape, e.g., a Y shape, and grid-like or braced walls. The carrier (7) preferably has the elongated or stretched, slender girder or rod shape shown. The carrier (7) has a plurality of prepared and preferably flat mounting surfaces for the machining units (8, 9). The cross section of the carrier (7) is preferably essentially rectangular and offers as a result different flat mounting surfaces on its side walls for the desired and also changeable arrangement of machining units (8, 9). In another variant, the carrier (7) may be designed as a plate or as a frame, etc.

The machining units (8, 9) are rigidly or detachably connected with the carrier (7). They have at least two separate axes of motion and may have any desired suitable design. The machining units (8, 9) may be arranged on different sides of the carrier (7) and may be present as multiple copies. They are arranged at the girder (7) according to the exemplary embodiment shown in Figures 2 and 3 at the side walls that are located opposite each other and are vertical in the stretched position being shown with an offset present in the axial direction ["im Axialrichtung" in line 7, p. 7 of German original should be "in Axialrichtung" - Tr.Ed.] or at spaced locations from one another. In the embodiment being shown, there are three left-hand machining units (8) and three right-hand machining units (9) in the top view according to Figure 3, and these said left-hand and right-hand machining units are arranged distributed at uniformly spaced locations from one another and are staggered between the left-hand and right-hand sides of the carrier. One or more machining units are additionally arranged on the top side and/or the underside of the carrier (7) in the variant according to Figure 6.

The machining units (8, 9) are preferably designed as small robots. These are six-axis articulated arm robots of the miniature format, which have, for example, a carrying capacity of 2 kg to 10 kg and an overall height h of about 65 cm. Figures 4 and 5 show such small robots (10). These are six-axis articulated arm robots, which have a frame (14) attached stationarily to the carrier (7), a carousel (15) mounted pivotably thereon, a rocker (16) mounted rotatably on the latter, and an extension arm (17) mounted pivotably at the end of the rocker. A three-axis robot hand (13), which carries the tool (11), is arranged at the end of the extension arm. An automatic change coupling may likewise be present here between the robot hand (13) and the tool (11). The small robot (10) shown may have auxiliary axes, for example, a seventh linear telescope axis for the robot hand (13), which makes possible an extending movement in relation to the extension arm (17). In addition, a linear axis, which makes possible a linear displacement of the entire small robot (10), may be present between the frame (14) and the carrier (7). The drives (18) of the small robot (10) are not shown for clarity's sake.

The tools (11) may be of any desired and suitable type. They are preferably machining tools, especially joining tools, e.g., clamping tools, welding tools, bonding tools or the like. The machining units (8, 9) and their tools (11) may be programmed individually and separately from one another in terms of their kinematics and functions. They are preferably controlled from the transport means (6). The end position of the machining units (8, 9) at the workpiece (2) can be maintained by control circuits, despite possible mechanical tolerances or flexibilities in the multirobot system. For example, the robot control of the transport robot (6) may be used for the control. The machining units (8, 9) are also supplied with energy and other materials needed for operation from the transport means (6) via the carrier (7).

The multirobot (5) may be used in different ways in the machining station (1). For example, it may move into the interior space (21) of the vehicle body (2) through a window or door opening or another opening with a docked multi-arm unit, i.e., the carrier (7) and the small robots (10). The small robots (10) with their tools (11) may be folded in in order to occupy the smallest possible space. The transport robot (6) will then position the carrier (7) with the small robots (10) in a predetermined starting position in the interior space (21) of the body. Figure 6 shows a schematic top view of such a working position corresponding to Figure 1.

The transport means (6) may hold the carrier (7) in the working position in a freely suspended manner. As an alternative, supporting by means of a support means (22) shown schematically in Figure 2 is possible. A column or a support (23), which may be arranged, e.g., at the pallet or the carrier of the component (2), at a lateral clamping frame (4) or at another point, is provided for this purpose at the working site in a suitable position. As an alternative, it is also possible to support the carrier (7) directly at the component (2), e.g., in an opening of the component, at a projection of the component or the like. The supporting may be positive-locking, such that the carrier (7) cannot move any longer in the supported position. This can be brought about, e.g., by the positive-locking mounting of the free end of the carrier in a corresponding opening of the column. As an alternative, it is possible to move the carrier (7) with the transport robot (6) in the supported position and to orient it in different angular positions. A sphere (24) may be arranged for this purpose at the free front end or another suitable point of the carrier (7), e.g., in the form of a joint, a cone or the like, which cooperates with a correspondingly shaped mount (25) at the column (23). The mount (25) may have, e.g., the shape of a flat spherical shell, a cone opening, a semicylindrical flute, etc. In the case of the ball arrangement shown in Figure 2, the transport means (6) can rotate the carrier (7)

about the longitudinal axis thereof and, in addition, about the two other rotatory space axes. Only rotation about the longitudinal axis of the carrier (7) is possible in case of a cone pair. In case of a flute-like mount (25), there may be a deliberate limitation of the rotary mobility depending on the direction in which the flute is open. The mount (25) may be accessible from the front, from the top and/or from the side. Depending on the embodiment, the supporting (22) may have one or more degrees of freedom with rotatory and/or translatory axes. Besides a rotary support, a supporting sliding guide is possible as well.

After the working position or optionally the supported position has been assumed, each small robot (10) can move out into its preprogrammed position and carry out the process assigned to it. The small robots (10) may carry out different processes, for example, a clamping process and a welding process. It is also possible due to the multi-arm unit to perform clamping tasks at different points in the interior space (21) of the vehicle body (2).

For example, two small robots (9, 10) arranged laterally at the carrier (7) clamp parts of one side wall (20) of the body (2) in Figure 6. A third small robot (9, 10') between them and on the top side of the carrier (7) carries out machining operations, e.g., welding operations, on the clamped side wall parts. On the other side of the carrier, a small robot (8, 10) clamps parts of the other side wall (19) of the body (2) in Figure 6, and an adjacent small robot (8, 10') performs machining operations in this area of the component.

After the conclusion of the handling and/or machining process, the small robots (10) with their tools (11) can again be folded in and removed from the vehicle body (2) together with the carrier (7).

Various modifications of the embodiments shown are possible. The machining device (5) may be present in a plurality of copies at the machining station (1). It may assume other positions and be arranged, for example, on the side and in an upright position. The number and the arrangement of the machining units (8, 9) at the carrier (7) may vary. This also applies to the design embodiment and also the control of the machining units (8, 9). These may be remote-controlled movement units with two or more axes, which are actuated and adjusted, for example, via bowden cables at the carrier (7). They are driven via a suitable adjusting device at the transport means (6) or at the carrier (7). The machining units (8, 9) and optionally their tools (11) may have freely programmable surfaces and optionally a memory effect. Furthermore, they may be coated with a flexible plastic coating.

LIST OF REFERENCE NUMBERS

1	Machining station, geo station
2	Component, body part
3	Station frame
4	Clamping frame
5	Machining device, multirobot
6	Transport means, transport robot
7	Carrier
8	Machining unit, left
9	Machining unit, right
10	Small robot
11	Tool, clamping tool
12	Machining device, welding robot
13	Robot hand
14	Frame
15	Carrousel
16	Rocker
17	Extension arm
18	Drive
19	Side panel, body
20	Side panel, body
21	Interior space of body
22	Support means, support
23	Column, support
24	Sphere, ball
25	Mount
h	Overall height of small robot